

First Assessment of Be Erosion Data in the JET ILW

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PSI-20, 24.05.2012*

Be erosion issues for ITER

- determines main wall life time
 - *LIM and ERO predict 1100-4200 shots due to sputtering data uncertainties – high and low margin estimates (PFMC-2011)*
- affects retention of tritium via co-deposition

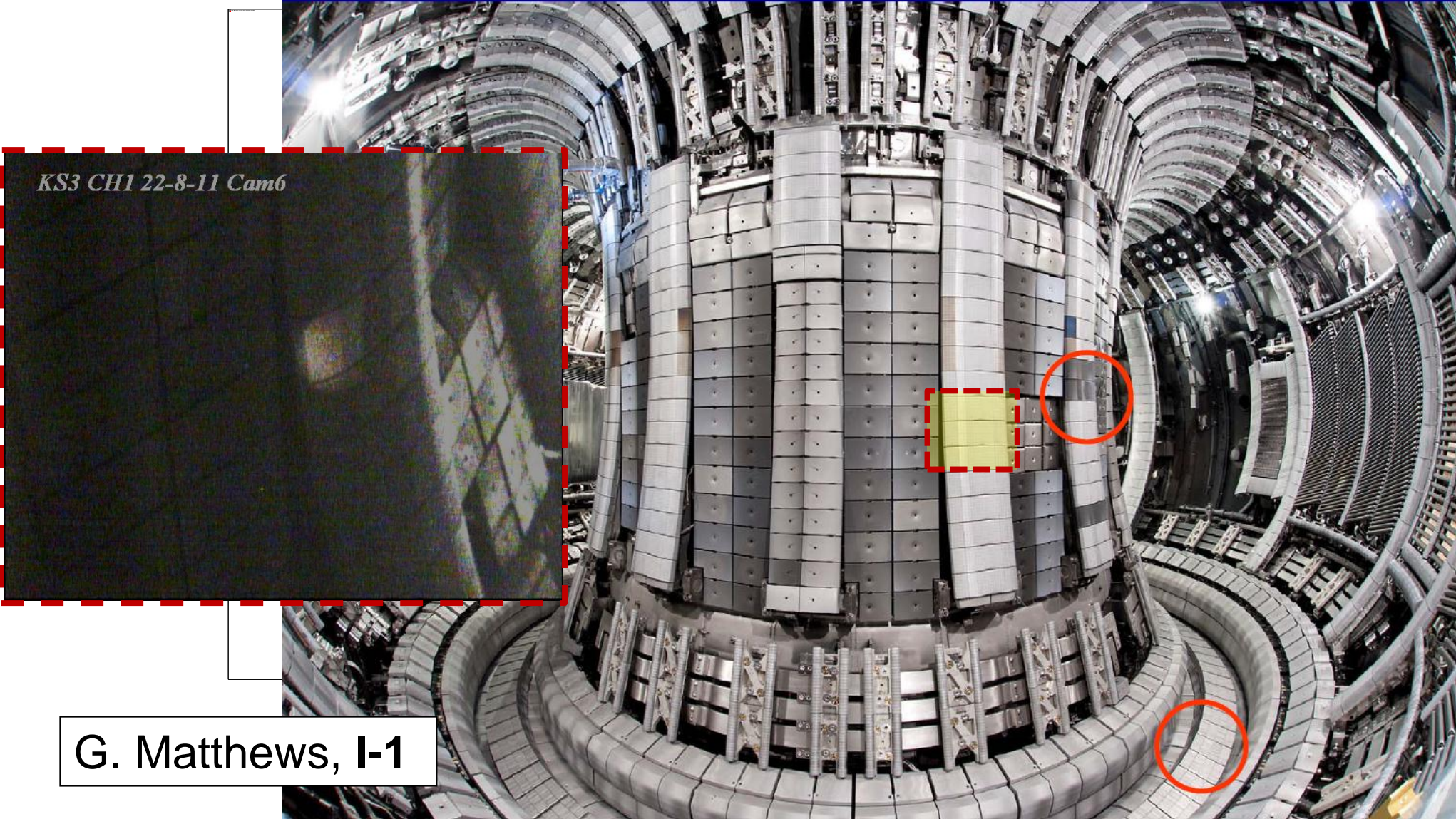
Only few relevant experimental observations

- JET ILW (Spectroscopy, ^{10}Be marker . . .)
- PISCES-B (Spectroscopy, weight loss, witness plate, . . .)

Aims:

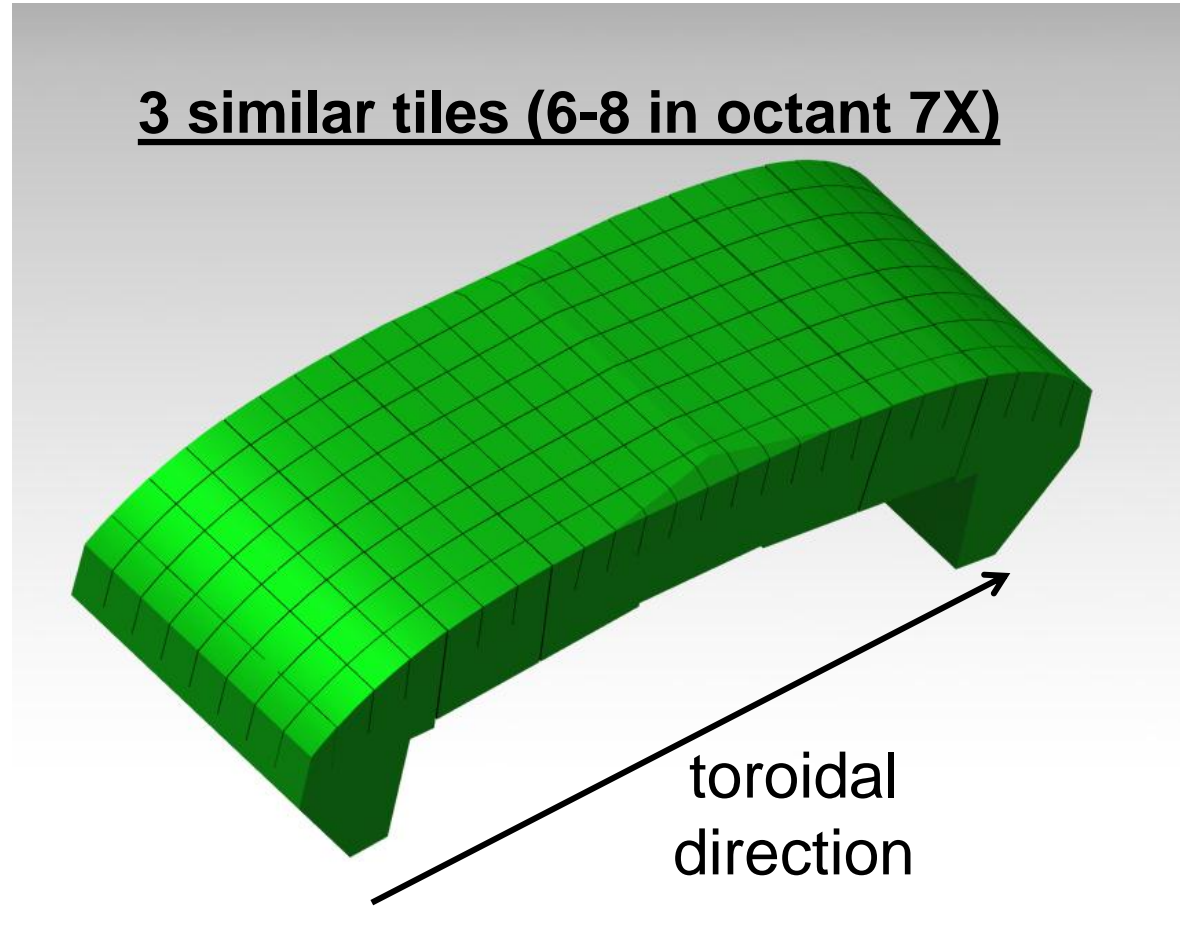
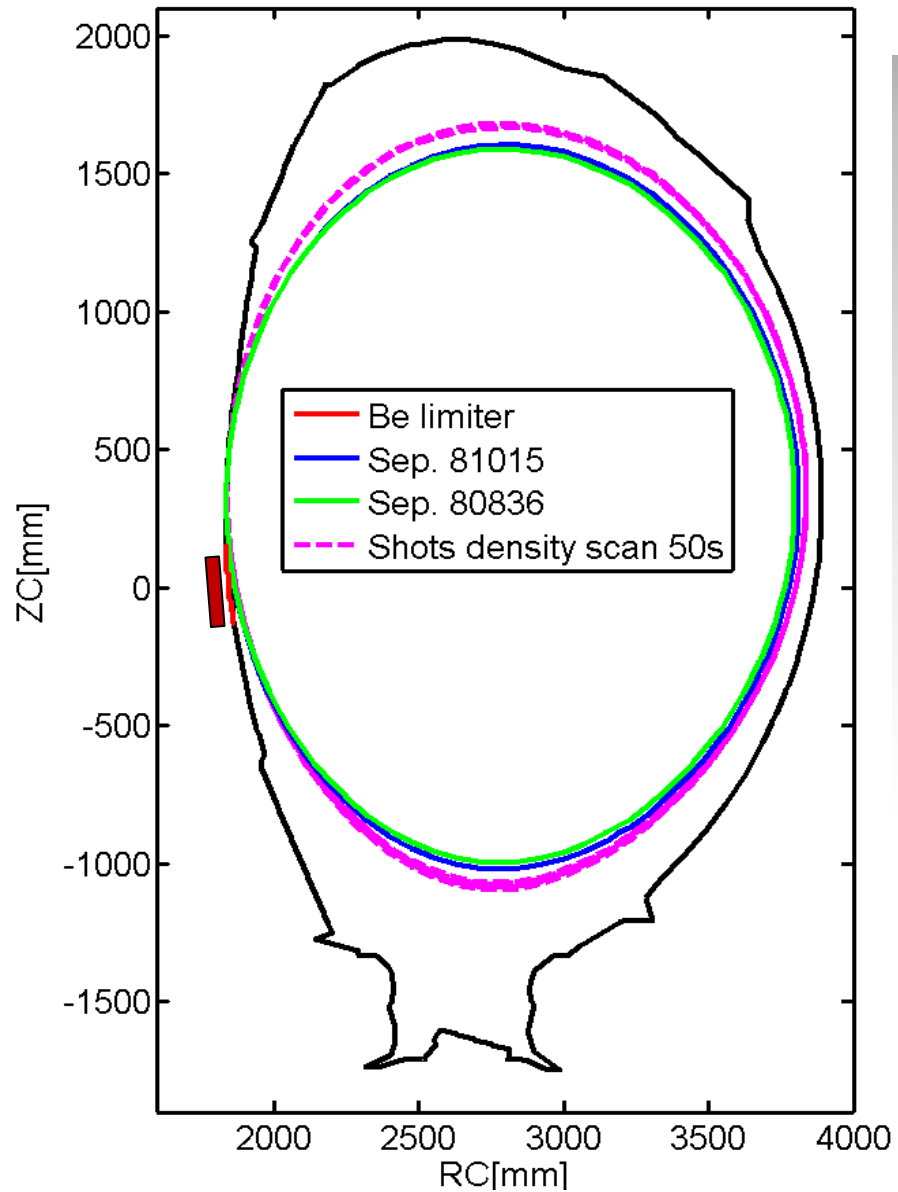
- ⇒ Understand and interpret experimental data
- ⇒ Verification of models and underlying data
- ⇒ Correct extrapolation for ITER

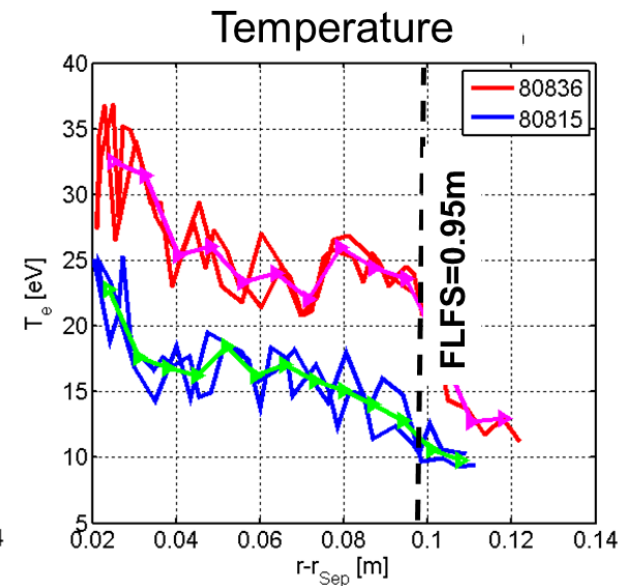
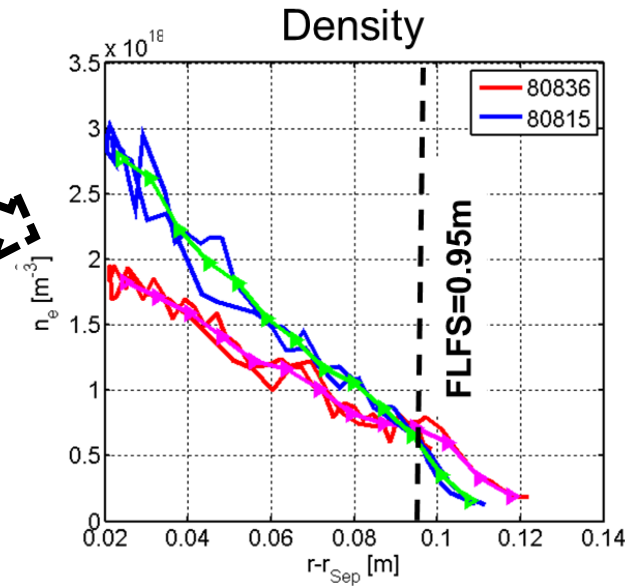
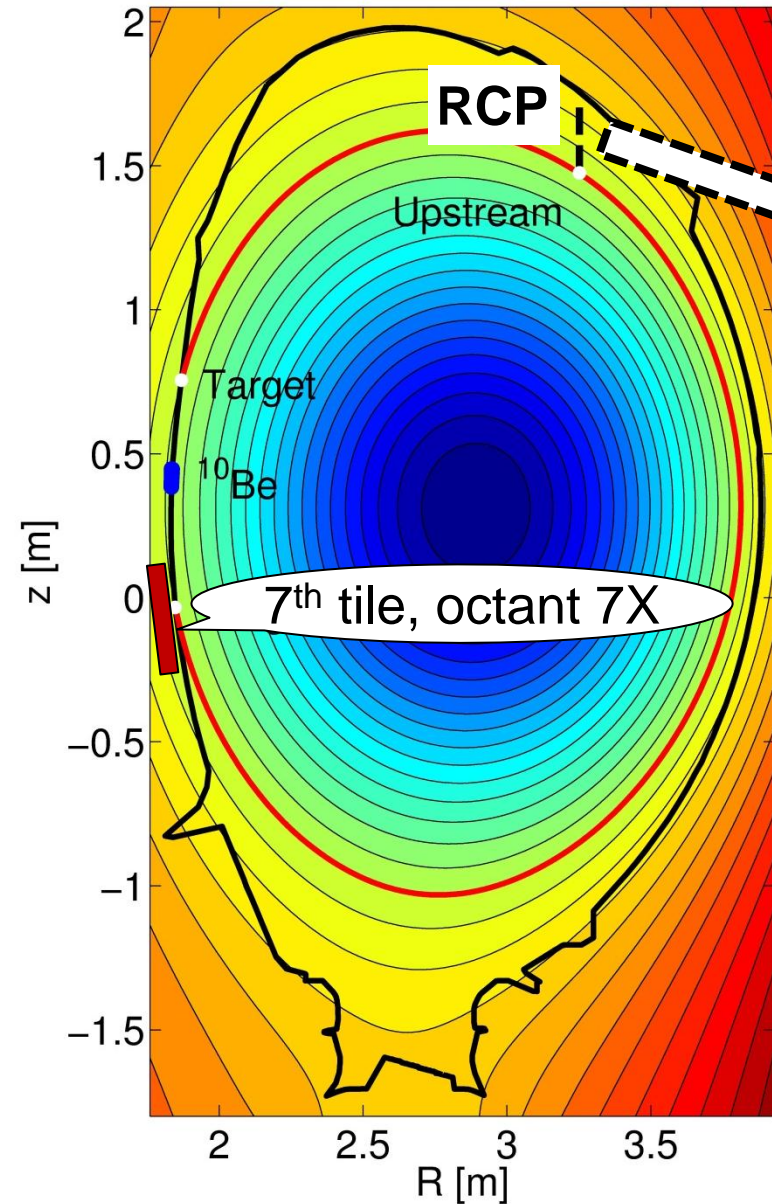
1. JET-ILW Be/W ITER-like Wall completed - 8th May 2011



KS3 CH1 22-8-11 Cam6

G. Matthews, I-1





RCP measurements mapped in 2D

- *2-point model as first approach for limiter plasma*

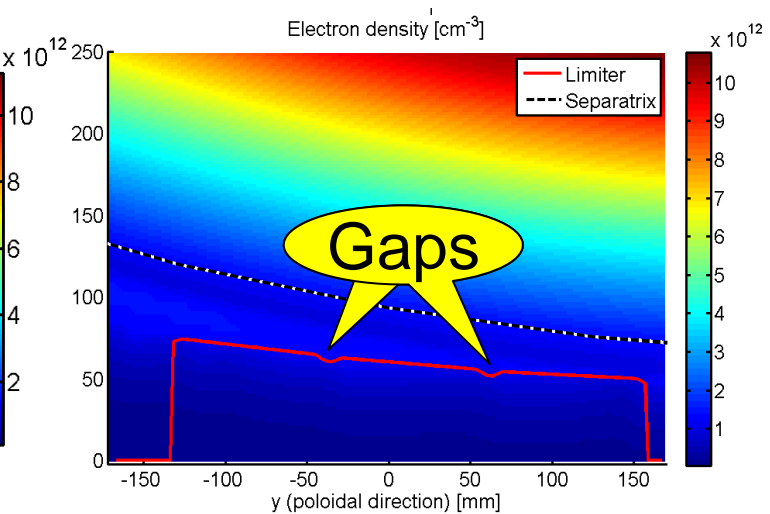
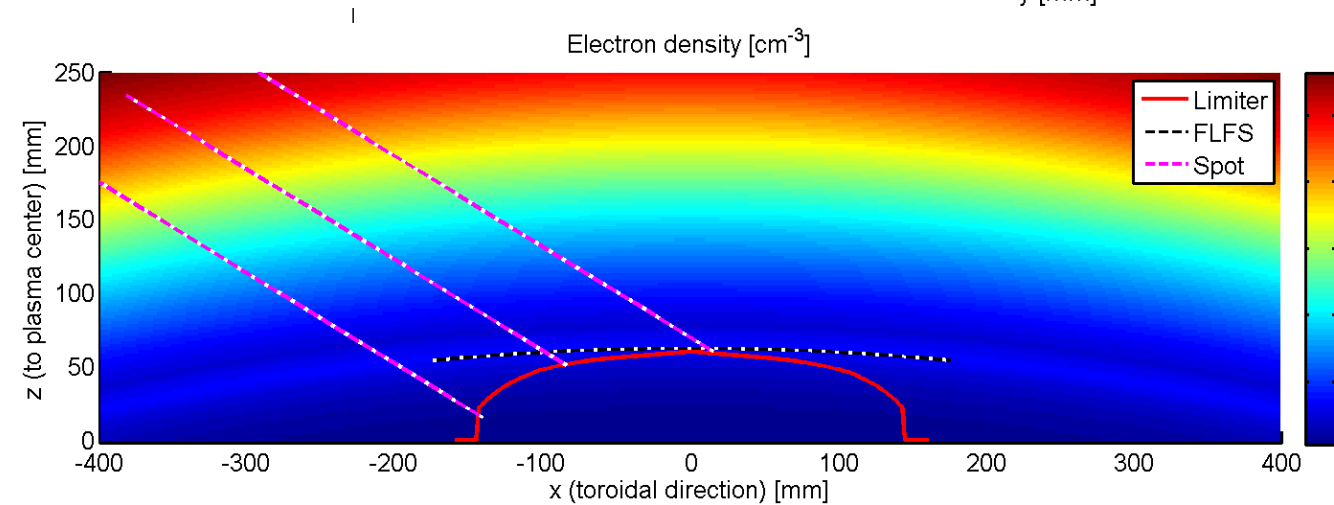
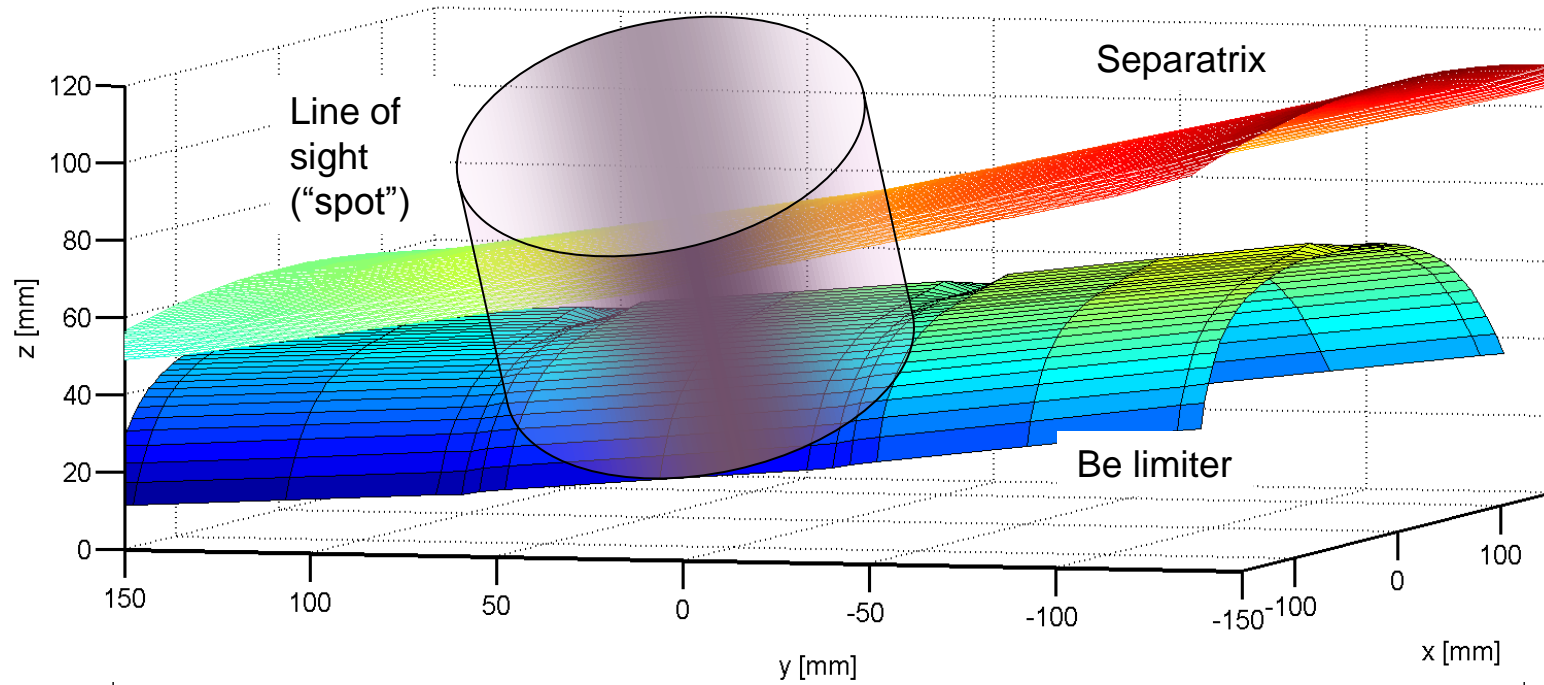
J.Miettunen
P1-90

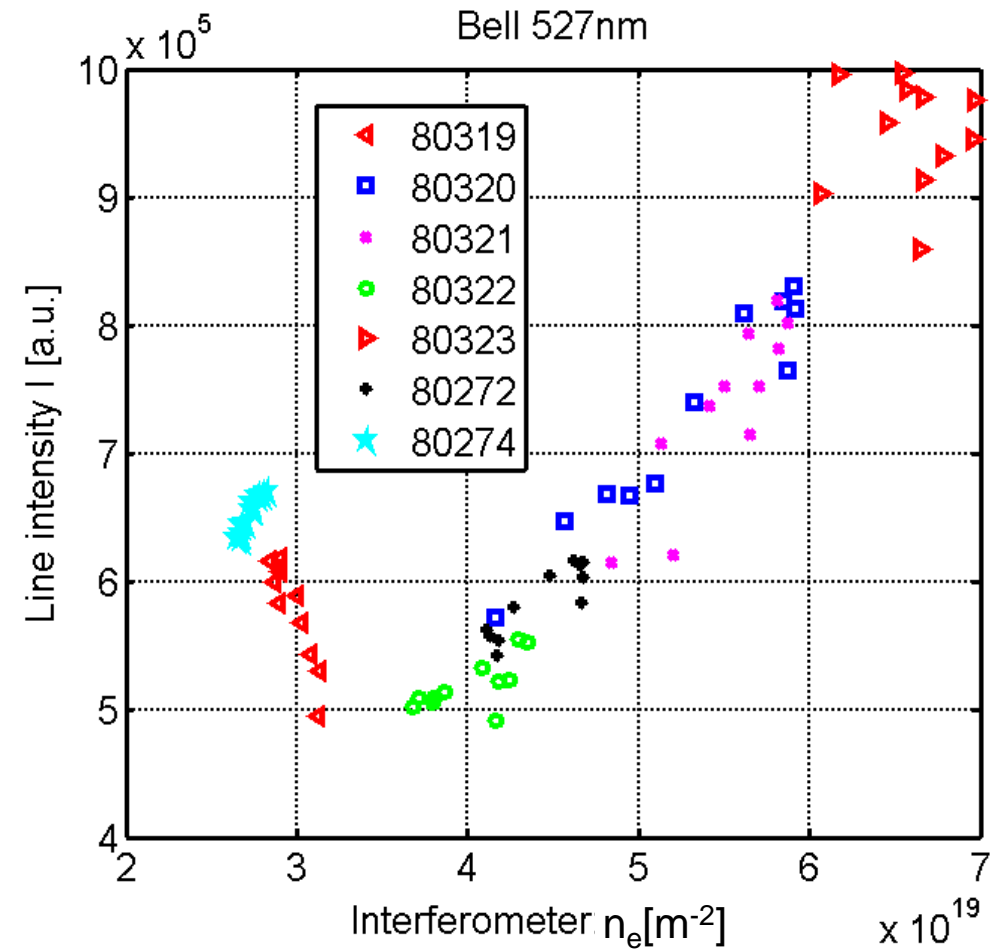
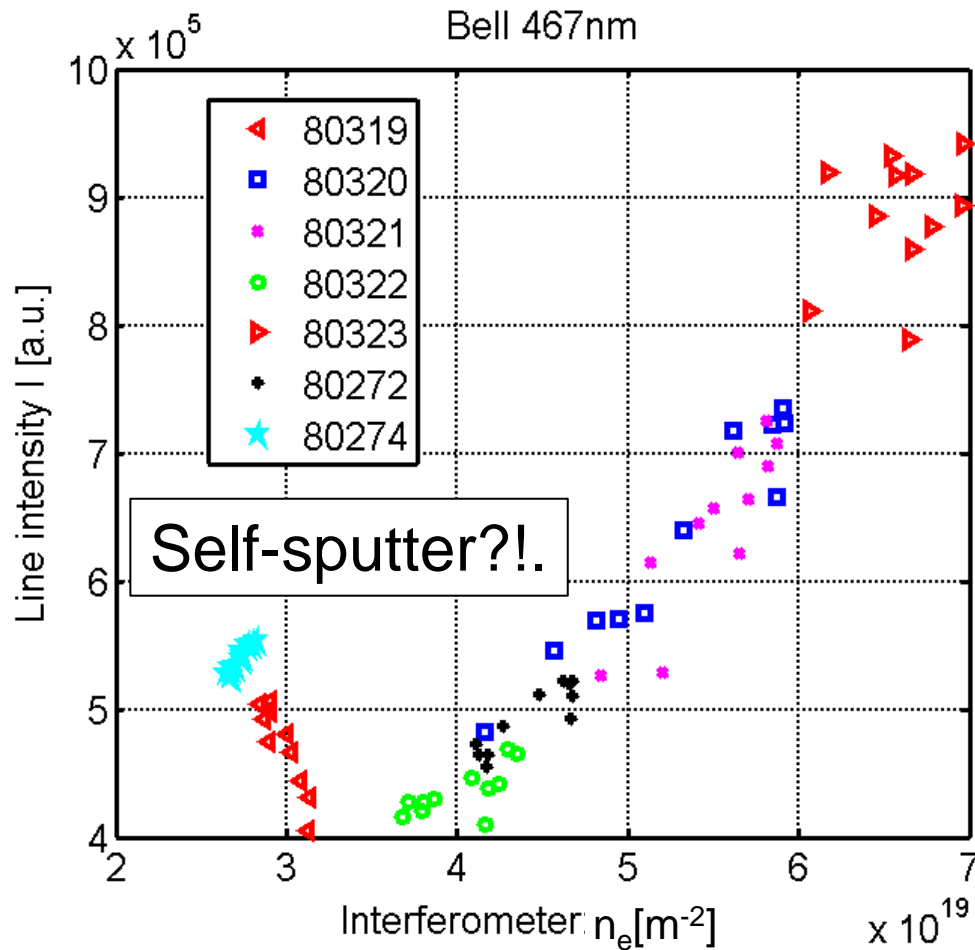
ERO assumes toroidal symmetry to get 3D . . .

Mapping only for 2 shots

- $< 4 \cdot 10^{19} \text{m}^{-2}$ „low density case“
- $> 8 \cdot 10^{19} \text{m}^{-2}$ „high density case“

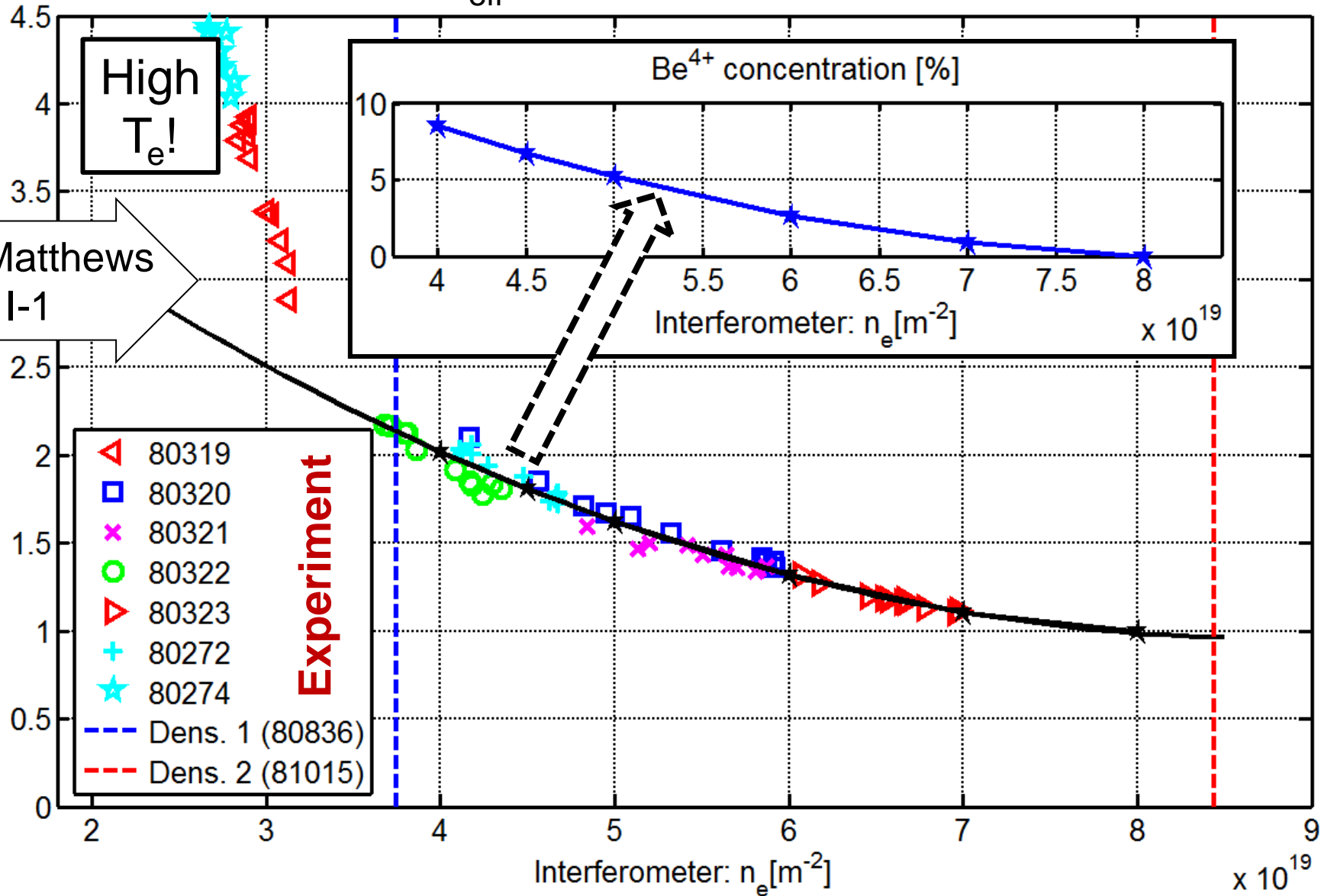
Density scan: linear interpolation





- **Similar behaviour for all Bell lines**
- Low density range means high local T_e : self-sputtering important
- High density range means low local T_e : photon efficiencies important

Z_{eff} measurement



Ratio of Be and D signal Intensity is a measure of the Effective Sputtering Yield

For an ionising plasma;

$$\text{Impurity influx } (\Gamma_{\text{imp}}) = I_{\text{imp}} * S/XB_{\text{imp}}$$

Deuterium flux to surface = flux leaving the surface

$$\text{D Flux } (\Gamma_{\text{d}}) = I_{\text{d}} * S/XB_{\text{d}}$$

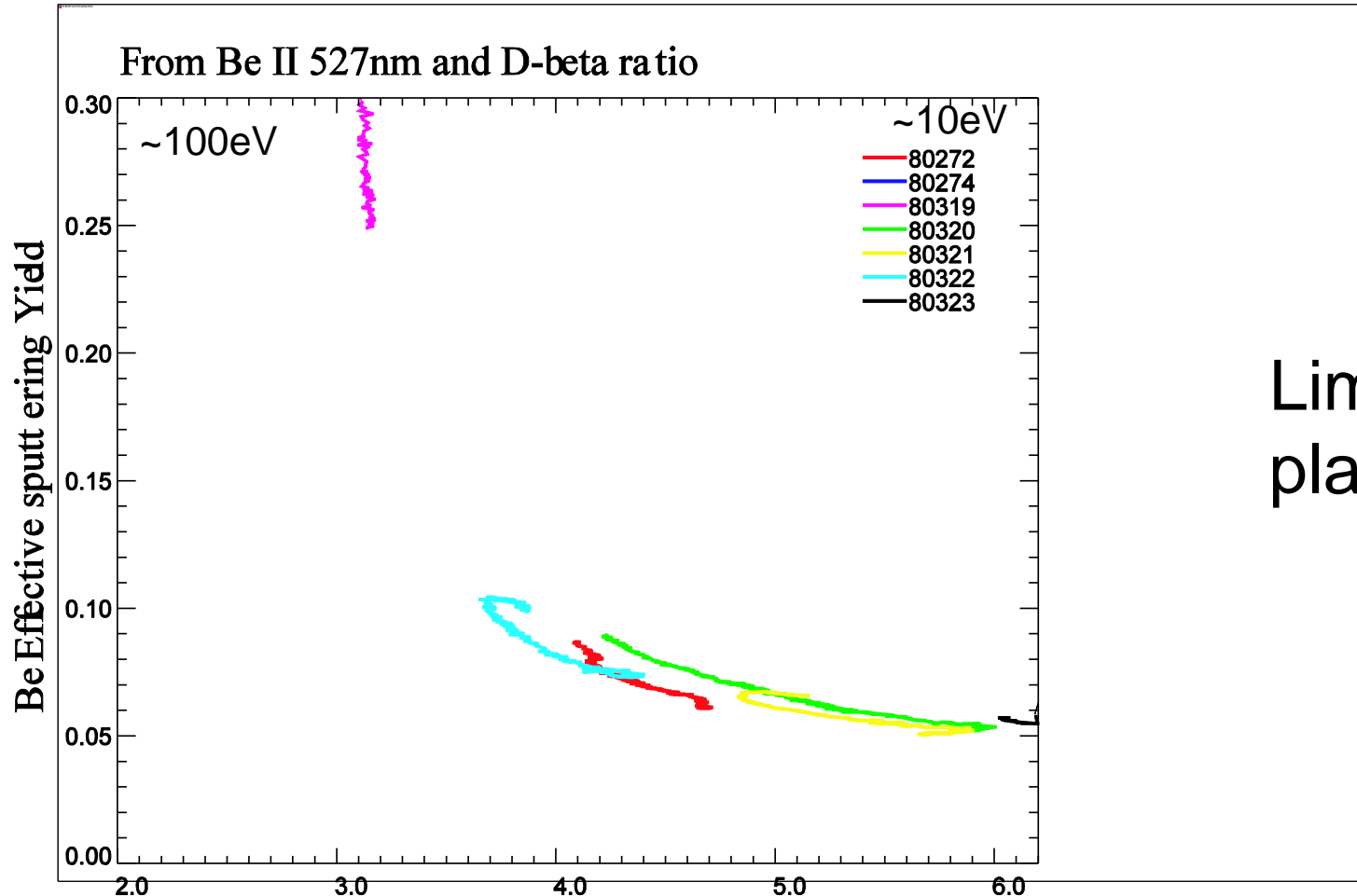
$$\text{Sputtering yield } (Y_{\text{d-imp}}) = \Gamma_{\text{imp}} / \Gamma_{\text{d}} = (I_{\text{imp}} / I_{\text{d}}) * (S/XB_{\text{imp}} / S/XB_{\text{d}})$$

In a tokamak plasma, in equilibrium, the impurity ions also return to the surface, and self-sputter with Yield, $Y_{\text{imp-imp}}$

Then

$$\text{Effective sputtering yield, } Y_{\text{eff}} = Y_{\text{d-imp}} / (1 - Y_{\text{imp-imp}})$$

Preliminary approximate Effective Sputtering Yield



Limiter
plasmas!

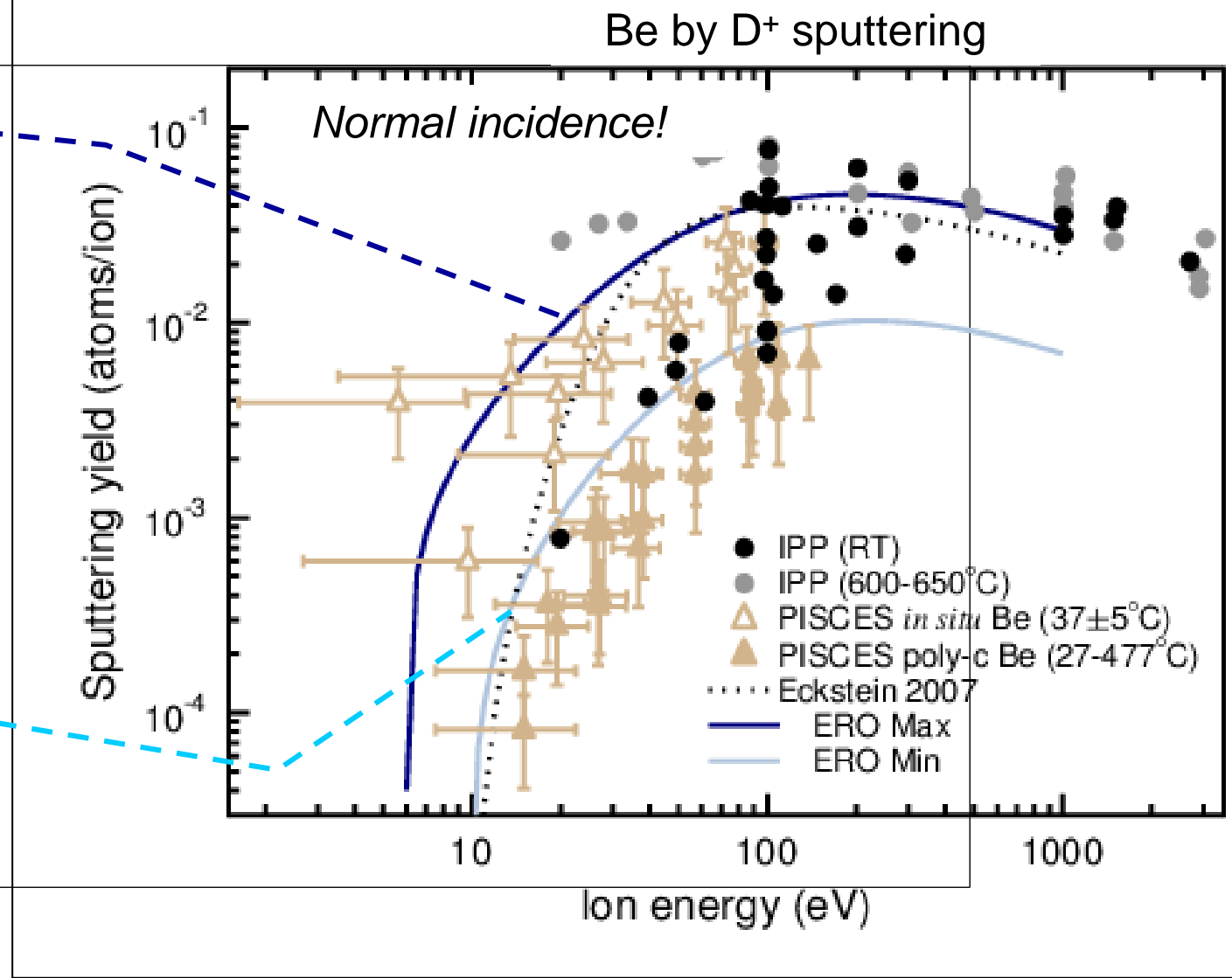
Interferometer: KGV/LID3 (10^{19} m^{-2})

Be effective yield below 10% at moderate to high density

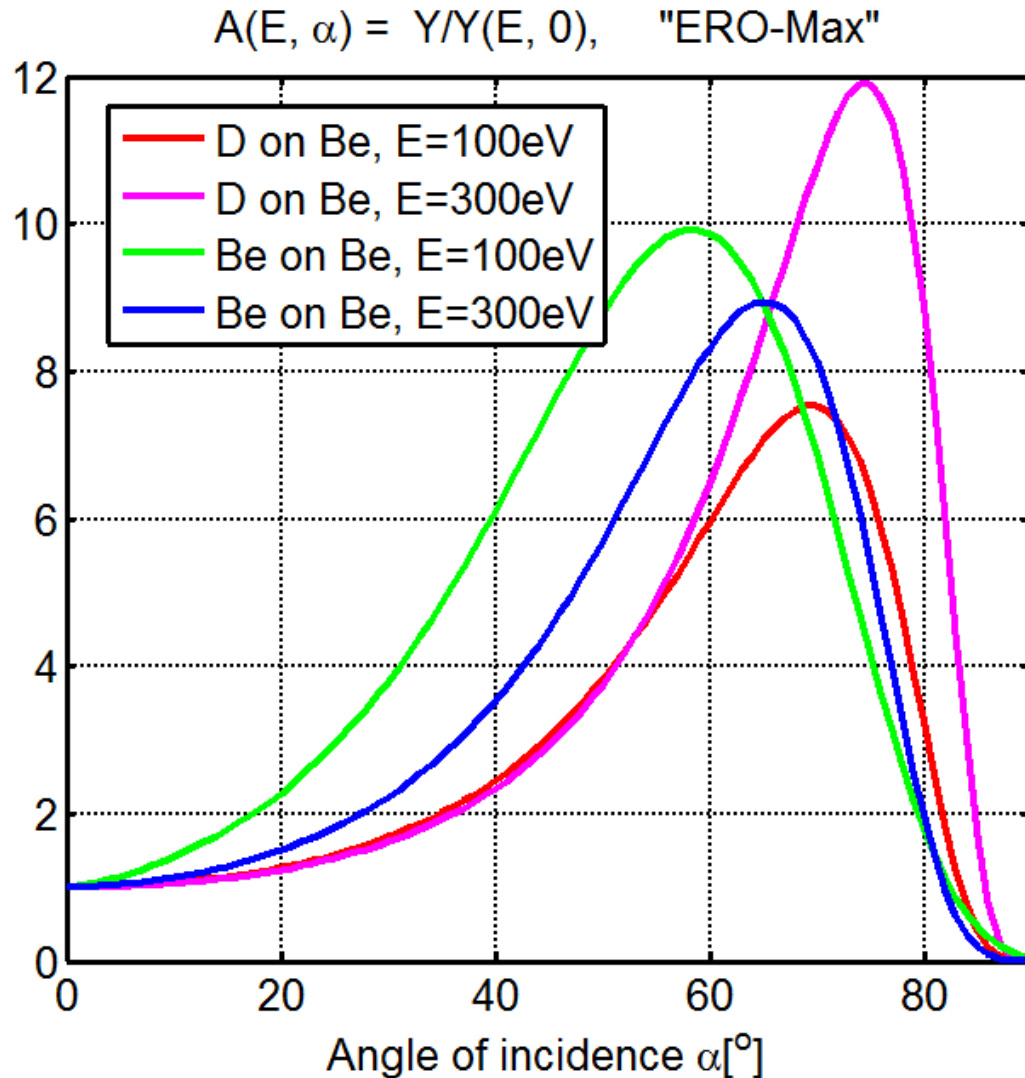
First modelling results

„ERO-max“
MD + SDTRIMSP
pure Be

„ERO-min“
SDTrimSP
50%Be + 50%D

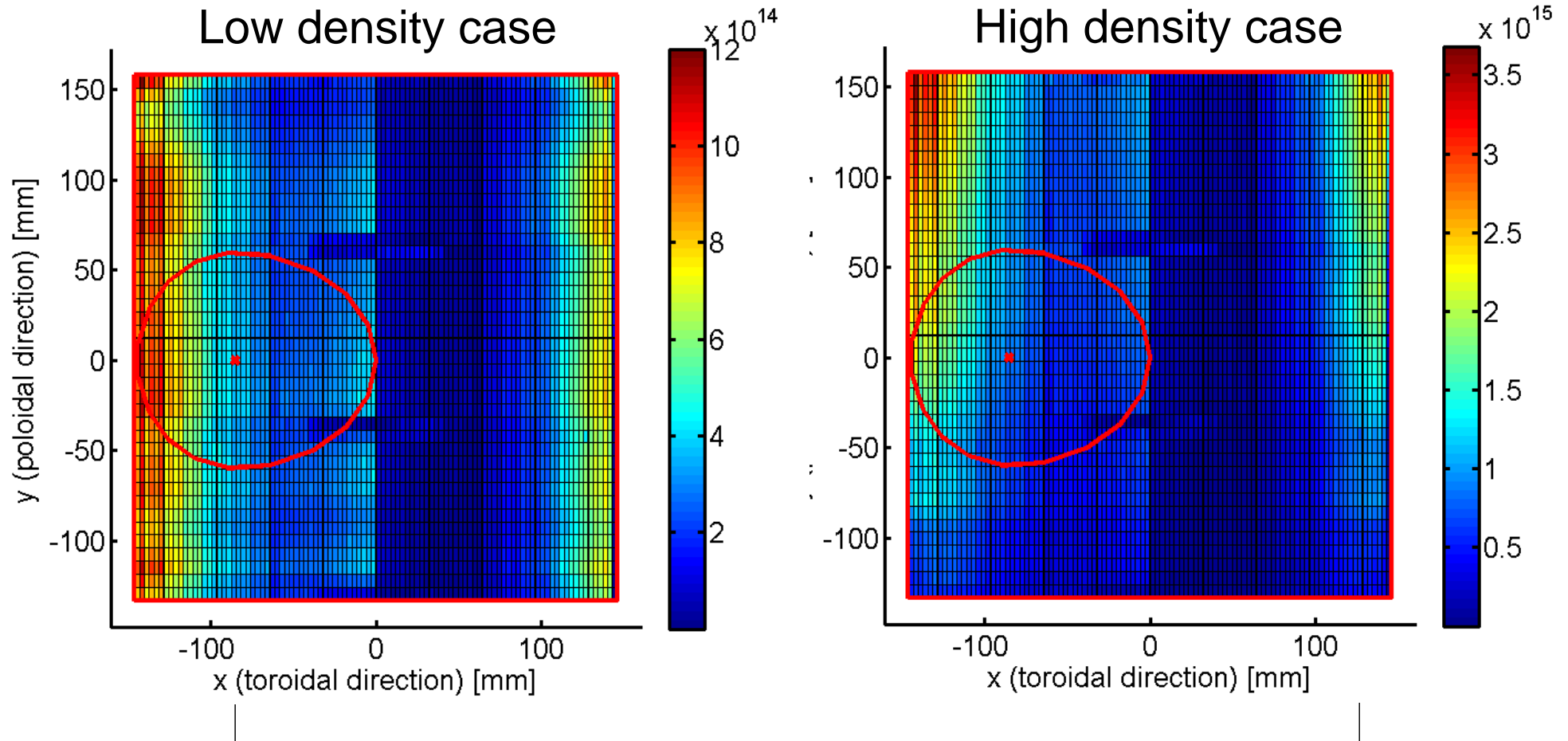


Important factor,
which is difficult to
take into account
w/o modelling!



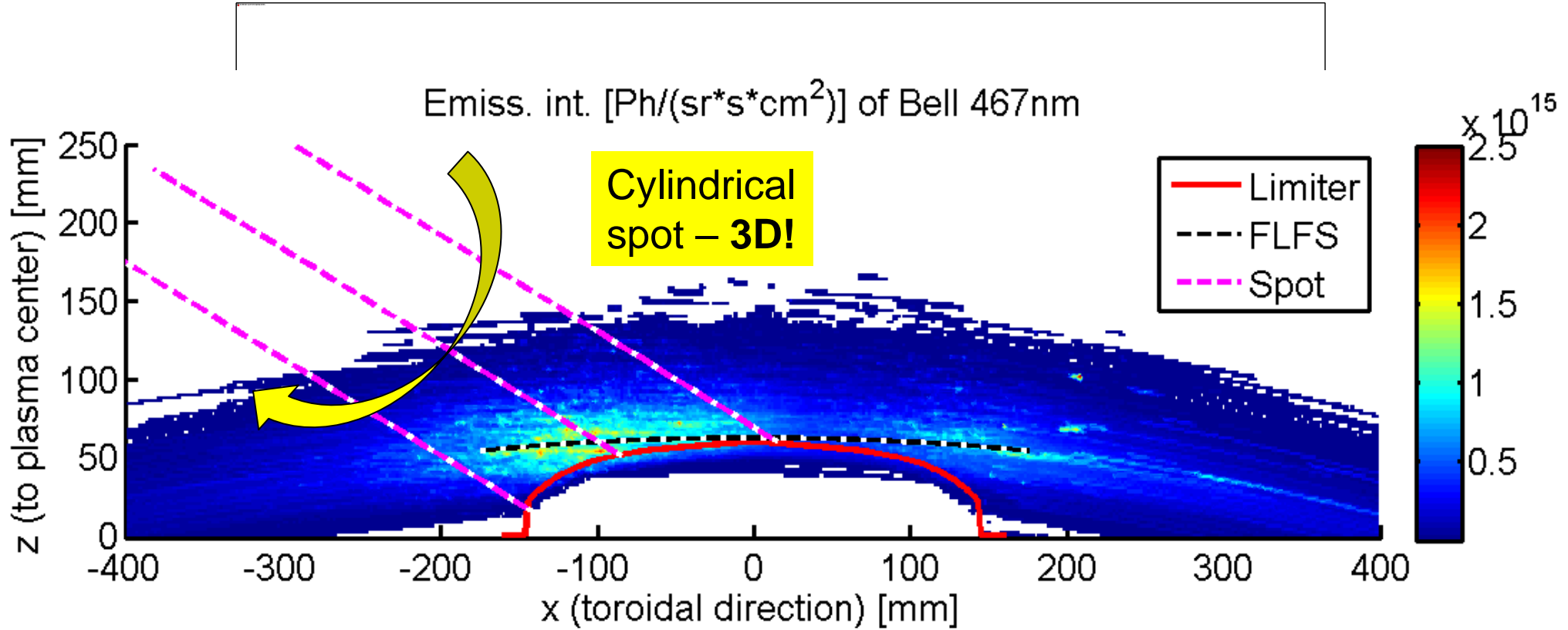
Eckstein 2007 fit

Limiter surface top view: eroded Be [atoms/cm²]



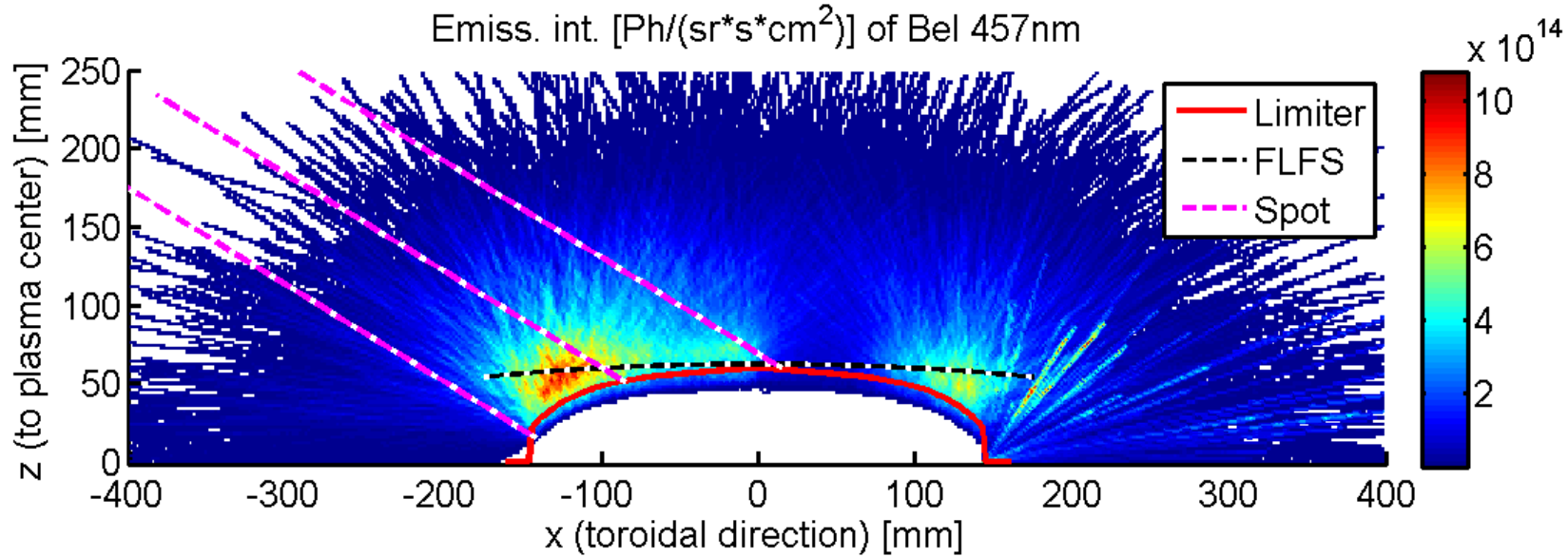
Possible impact on light intensity in spot is obvious!

Example: Be⁺, high density

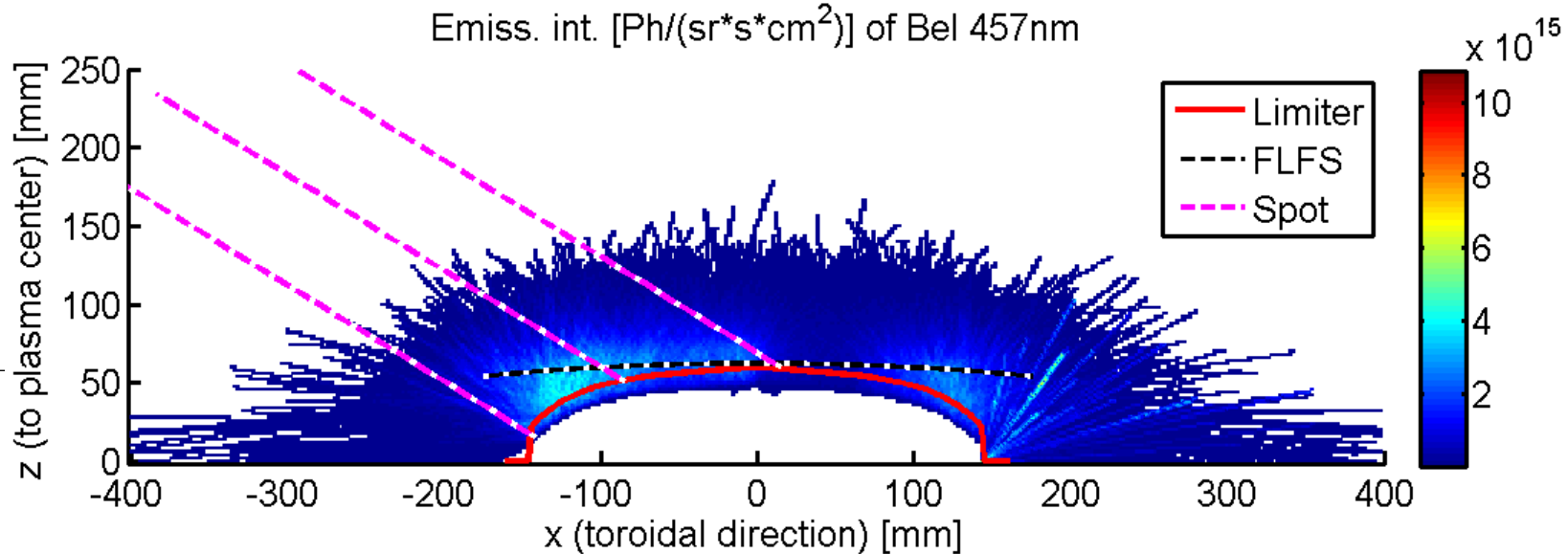


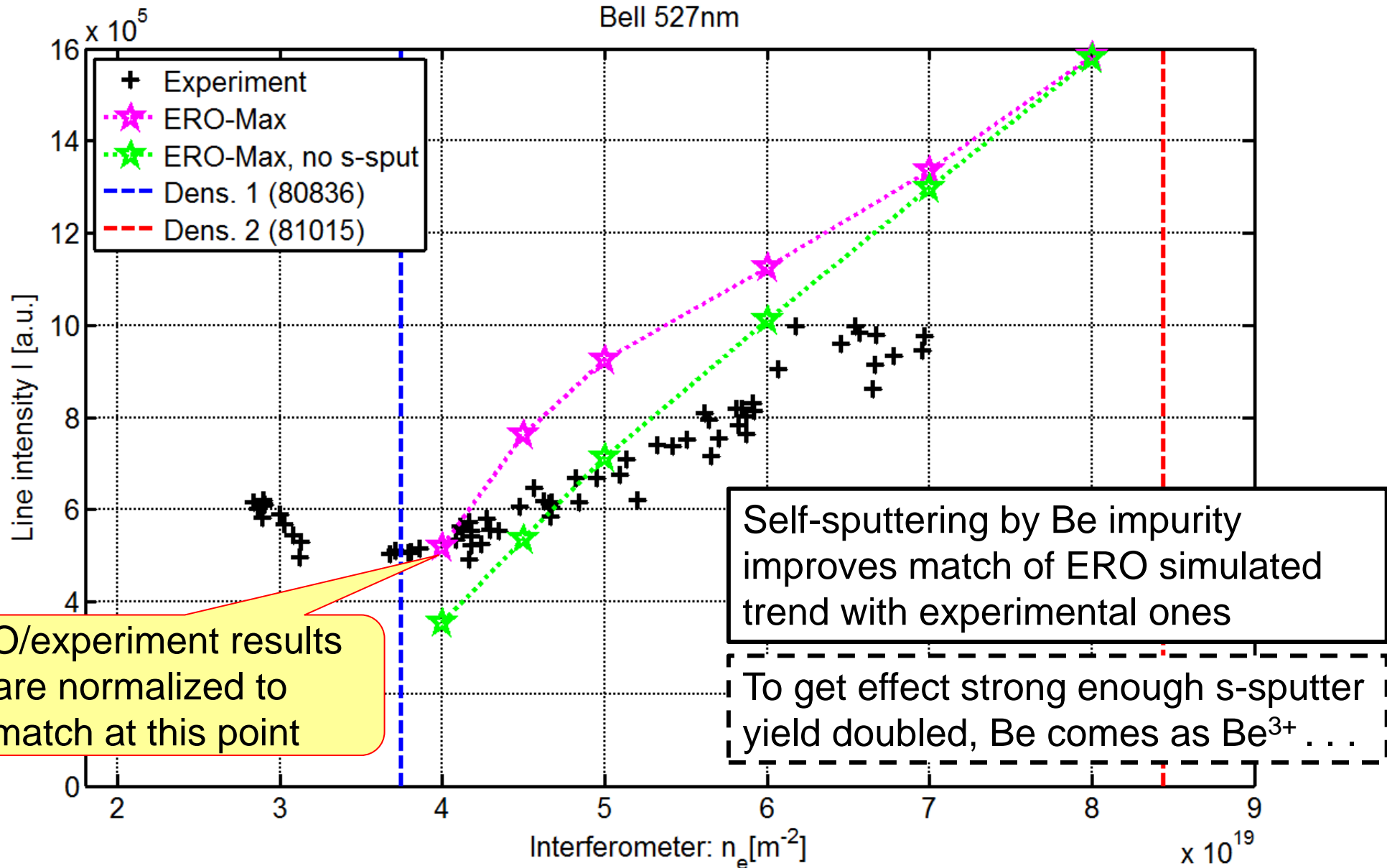
Transport into the spot of Be eroded elsewhere! . .

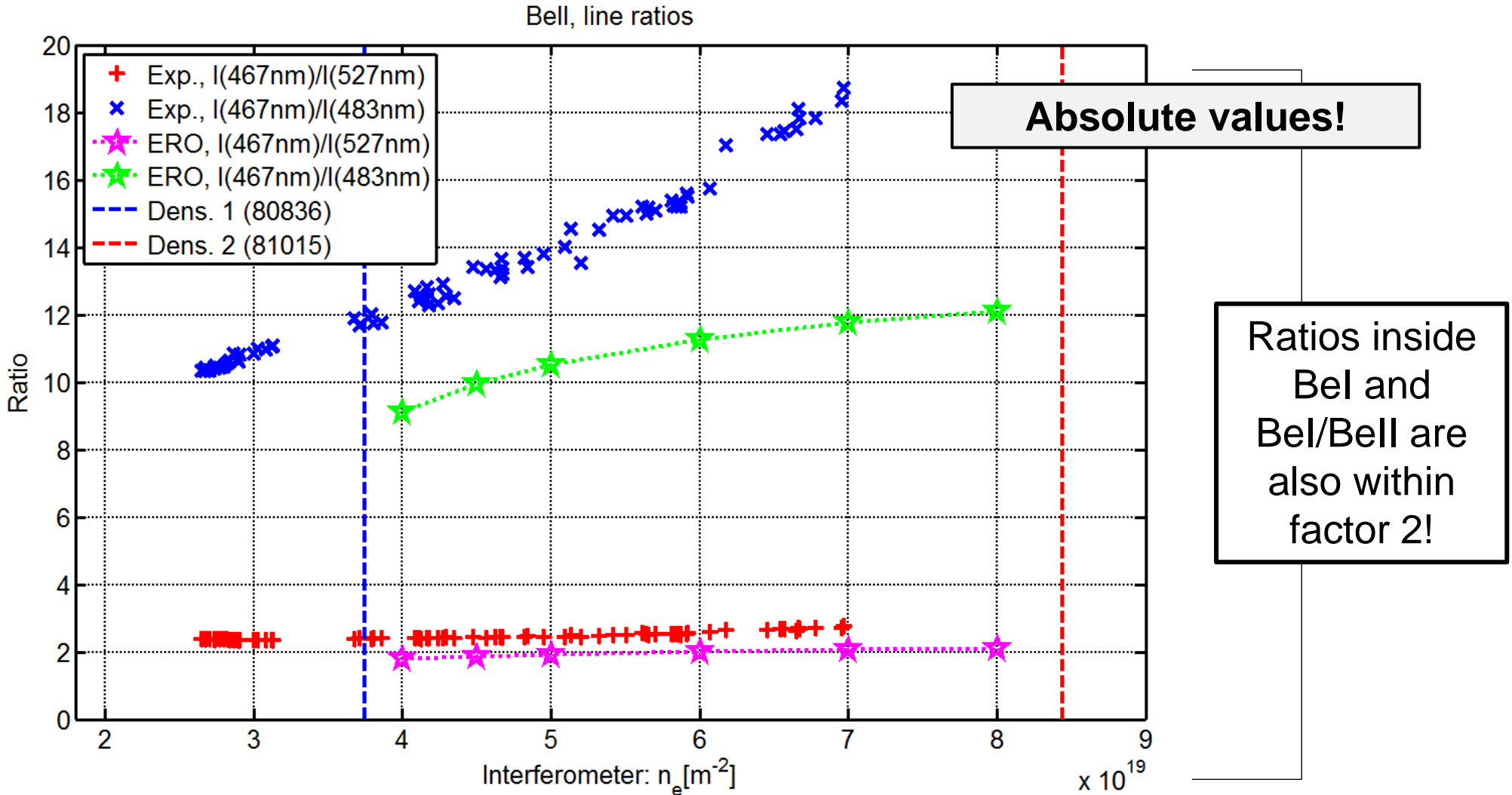
Be⁰,
low density



Be⁰,
high density







Indicates that atomic data (ADAS '96') and simulated Be transport (3D density pattern) are reasonable!

The ERO modelling can also be refined by taking other effects into account

1. Refined treatment of intrinsic Be plasma impurity

➤ *Periodic boundary?..*

2. **Be-D molecules** as additional erosion and transport mechanism

➤ *BeD light observed by the same system! ..*

3. **3DGaps** consideration of gaps between tiles (*poster D.Matveev*)

4. **enhanced re-erosion** of freshly deposited Be

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There is a number of complicated issues, however solutions are being developed!

1. The **spectroscopic observation** of **Be** species eroded from the massive shaped limiter of JET ILW during the plasma density scan allows to estimate the effective **sputtering yield** using S/XB approach.
 - < 10% – larger than e.g. Eckstein 2007 values, however can be explained by the role of Be self-sputtering.
2. The first **application of 3D ERO** code to the experiment illustrates the potential improvement in the experiment interpretation.
 - Geometry and plasma parameters, density scan introduced into the code
 - This allows to include the influence of detailed geometry, transport and spectroscopic issues, interplay of various effects . . .
3. The current uncertainties in the plasma parameters (ERO input) and unconsidered effects does not allow so far to use modelling for **precise judgment** about physical **erosion data**. Still, it was possible to reproduce main trends and line intensity ratios during density scan – this indicates modelling reasonability.

This work demonstrates a principal possibility of erosion data assessment by the described spectroscopic measurements in combination with detailed 3D modelling